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FINAL REPORT

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Submitted by:

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Introduction

This final report summarizes the work performed by the University of Massachusetts (UMASS) for the NASA grant NAG5-5151 entitled, "RADARSAT Underflights: Comparison of C-band VV and HH Backscatter-Wind Retrieval". The primary objective of this grant was to validate the modified CMOD4 wind speed algorithm used to invert RADARSAT data. We proposed to do the following:

- TASK 1: Participate in at least two underflights of RADARSAT collecting backscatter measurements with the UMASS C-band and Ku-band scatterometers, CSCAT and KUSCAT.
- TASK 2: Process data gathered with CSCAT and KUSCAT into one kilometer along-track pixels with each pixel consisting of seventy-two five degree azimuth bins - each bin containing normalized radar cross section (NRCS) values for that particular azimuth angle and for each of the four incidence angles viewed by CSCAT and KUSCAT. Derive wind speed and direction estimates from each NRCS along-track pixel using CMOD4 and NSCAT1 models.
- TASK 3: Compare collocated CSCAT vertically polarized (VV) and RADARSAT horizontally polarized (HH) NRCS data and wind estimates, and based on the comparison, evaluate the performance of the modified CMOD4 wind speed algorithm to invert RADARSAT NRCS measurements.

The first two tasks were completed. The third task is still on-going since the RADARSAT data for the underflights has not been released to the University of Massachusetts. We expect that the RADARSAT data will become available in the next few months, and we will complete the third task in a promptly manner once the data has been received. Below the missions flown and the data collected are summarized.

Experiment Summary

Two missions, based out of the NASA Wallops Flight Facility, were flown. The first flight was on 21 September 1997 and the second on 24 September 1997. The ons-tation time for each mission was approximately 2 hours. Figure 1 plots the flight tracks and marks the location of the NOAA buoys that were in the vicinity. The wind speed and direction recorded by each buoy during the flight are shown by the wind barbs. Surface wind speeds from approximately 2 m/s to 10 m/s were observed with CSCAT and KUSCAT.

Data Summary

CSCAT and KUSCAT measured the backscattered power from a common ocean surface area at four incidence angles - 22.0°, 32.3°, 43.5° and 54.1° for CSCAT; 20.0°, 30.5°, 40.9° and

50.9° for KUSCAT - as they conically scanned at 80 rpm. The backscatter measurements from a single conical scan were subdivided into seventy-two five degree azimuth bins, with each bin being the average of approximately 13 samples. The averaged measurements were then corrected for gain drifts and the receiver noise power was subtracted. The aircraft platform data was used to reference each azimuthal bin to true North and to calculate the instantaneous incidence angle for computation of the NRCS. The pitch and roll motions of the aircraft caused the instantaneous incidence angle to vary about the nominal pointing angles. Using CMOD4 and NSCAT1, corrections were applied to the NRCS measurements to normalize them to the nominal pointing angles of each system. These corrections were small, and they were only applied to those data where the instantaneous incidence angle was within 2° of the nominal pointing angle.

The NRCS data were then binned into one kilometer along-track pixels and averaged. That is, the data at each azimuth bin were averaged as the aircraft traversed across each one kilometer along-track pixel. From these averaged NRCS azimuth bins, complete azimuthal scans were reconstructed. Using wind speed algorithms based on CMOD4 for C-band and NSCAT1 for Ku-band, wind speed and directions estimates were derived from the averaged NRCS scans. A median filter was used to remove ambiguities in the wind direction estimates. Figures 2 and 3 plot the wind vector estimates derived from CSCAT data gathered at each incidence angle on 21st and 24th of September. Likewise, figures 4 and 5 plot the wind vector estimates derived from KUSCAT data. Wind estimates from all four incidence angles and both frequencies agreed within ≈1 m/s for both flights.

Low to moderate wind speeds were sampled which will provide an excellent range of wind speeds for our comparison with RADARSAT data. On September 21, the sampled surface winds varied from 3 m/s to as high as 10 m/s around NOAA buoy 44025. The wind direction was from the northwest. On September 24, the surface winds changed from 2 m/s near the coast up to 8 m/s passed the Gulf Stream. The wind direction remained fairly constant from the northeast.

Planned Analysis

Upon receiving the RADARSAT data, UMASS will collocate the RADARSAT data with each along-track NRCS pixel measured by CSCAT. The NRCS values will be plotted against one another to determine the relationship between VV and HH NRCS. The sensitivity of HH NRCS to wind speed will be compared to that of VV NRCS. Finally, the retrieved wind speeds and directions will be compared. This comparison will be used to evaluate how well the modified CMOD4 model function describes the relationship between HH NRCS and the 10 m neutral stability wind. A summary of these comparisons will be sent as an addendum to this report.

by the circles. The recorded wind vectors at the time of the flights are shown at each buoy

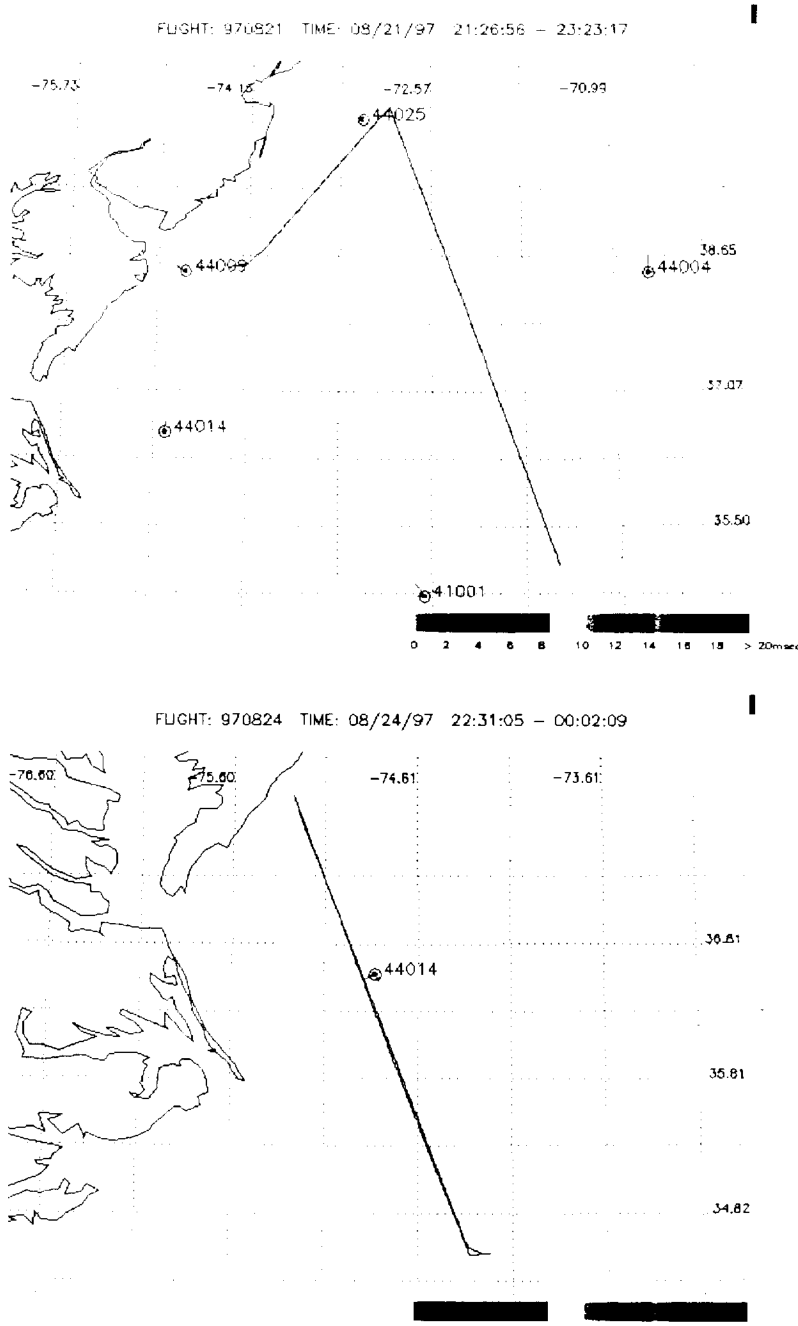

Figure 1: Flight tracks for 970821 and 970824 are plotted. NOAA ocean buoys are shown by the circles. The recorded wind vectors at the time of the flights are shown at each buoy location.

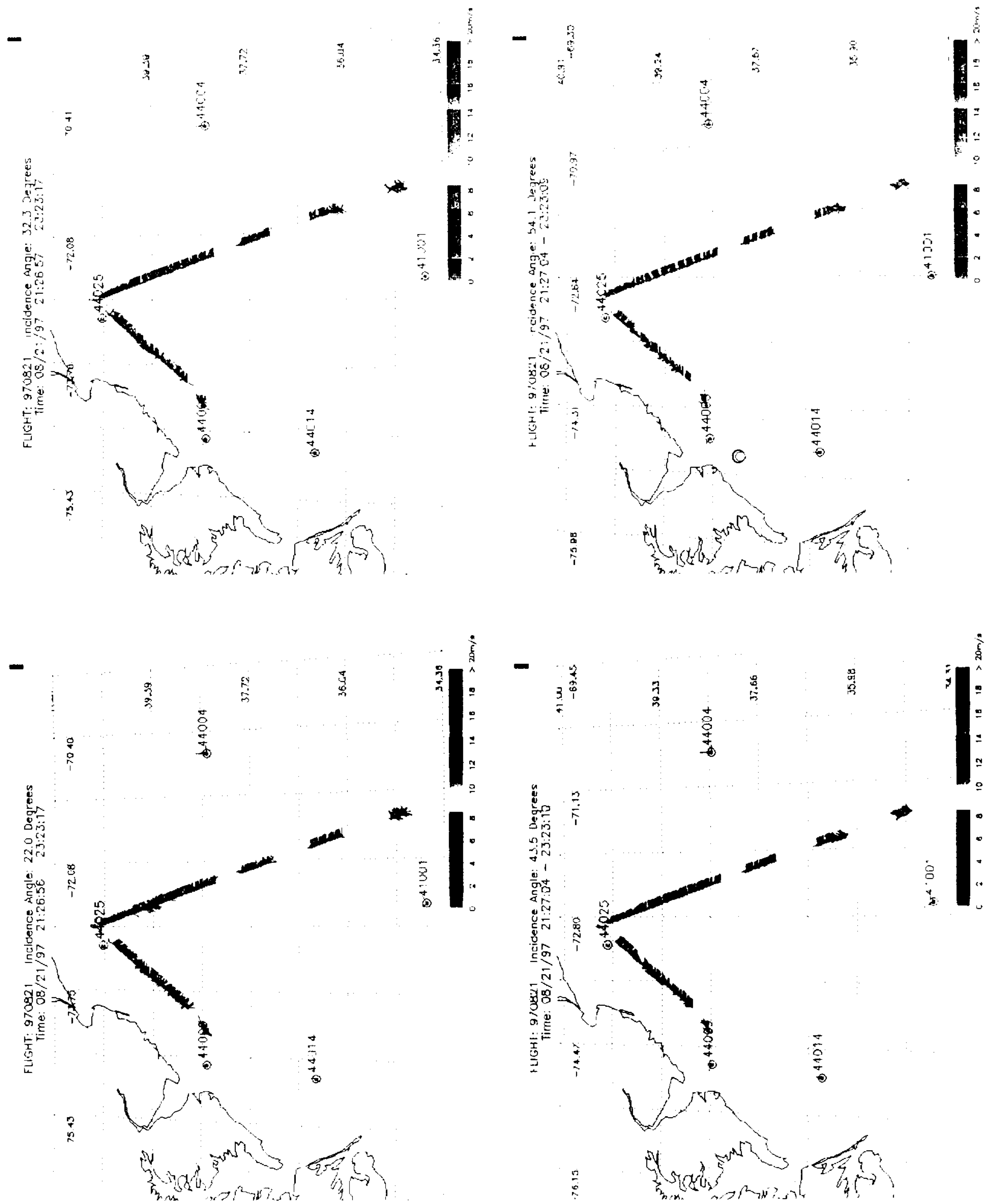

Figure 2: Plots wind vector estimates derived every one kilometer from CSCAT data collected at 22°, 32.3°, 43.5° and 54.1° incidence on 21 September 1997. NOAA buoy locations and wind vector measurements at the time of the flight are also shown.

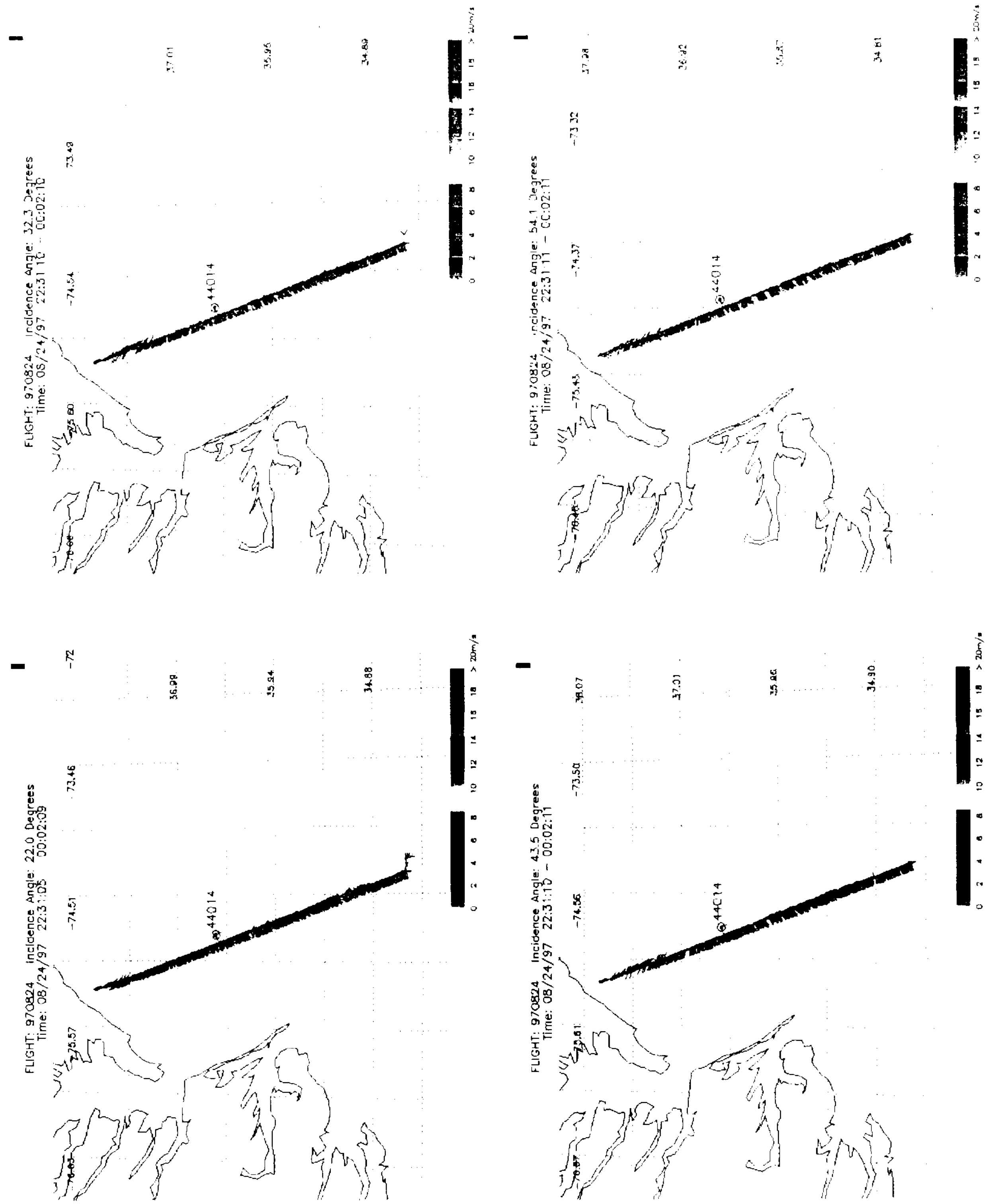

Figure 3: Plots wind vector estimates derived every one kilometer from CSCAT data collected at 22°, 32.3°, 43.5° and 54.1° incidence on 24 September 1997. NOAA buoy locations and wind vector measurements at the time of the flight are also shown.

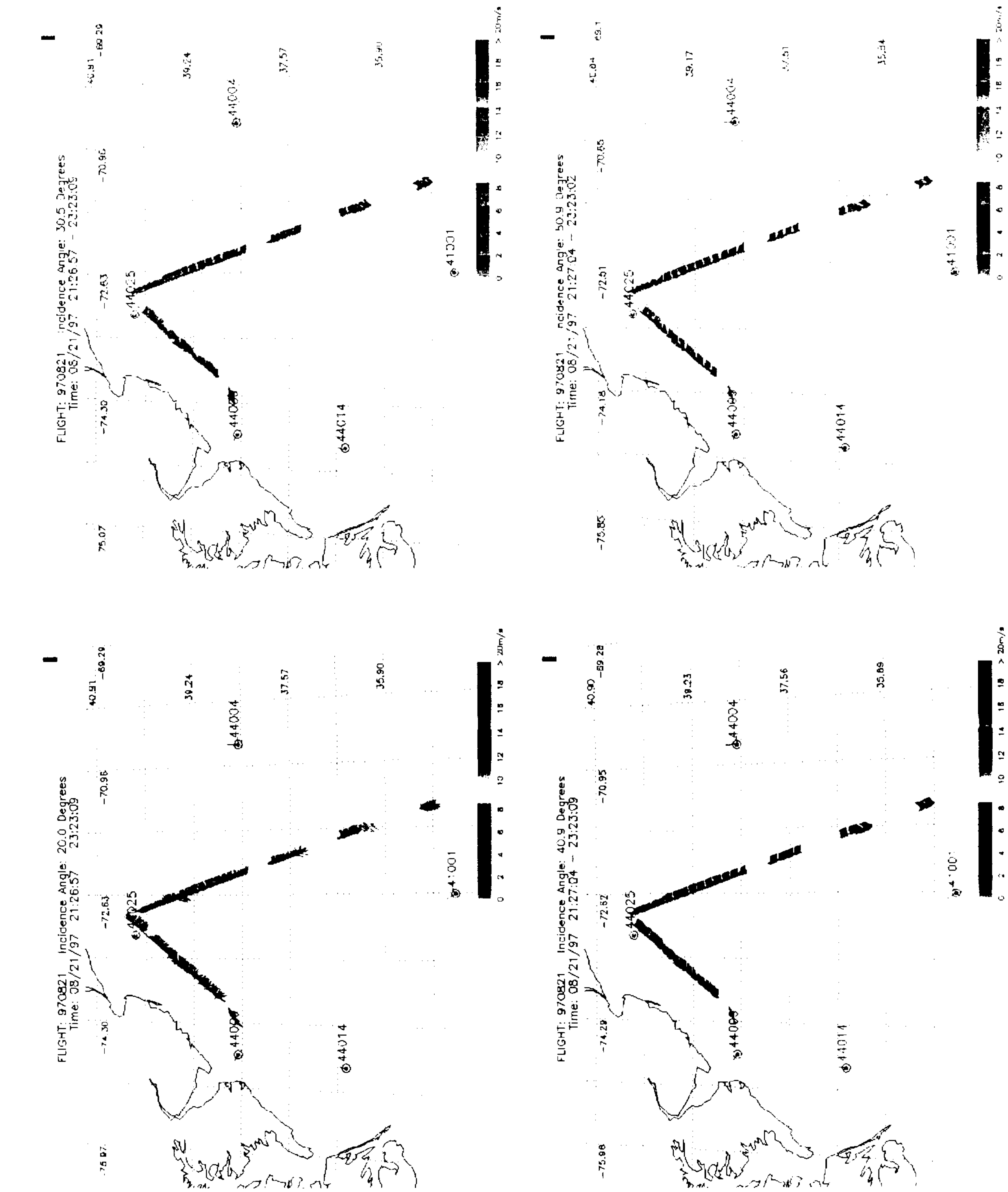

Figure 4: Plots wind vector estimates derived every one kilometer from KUSCAT data collected at 20°, 30.5°, 40.9° and 50.9° incidence on 21 September 1997. NOAA buoy locations and wind vector measurements at the time of the flight are also shown.

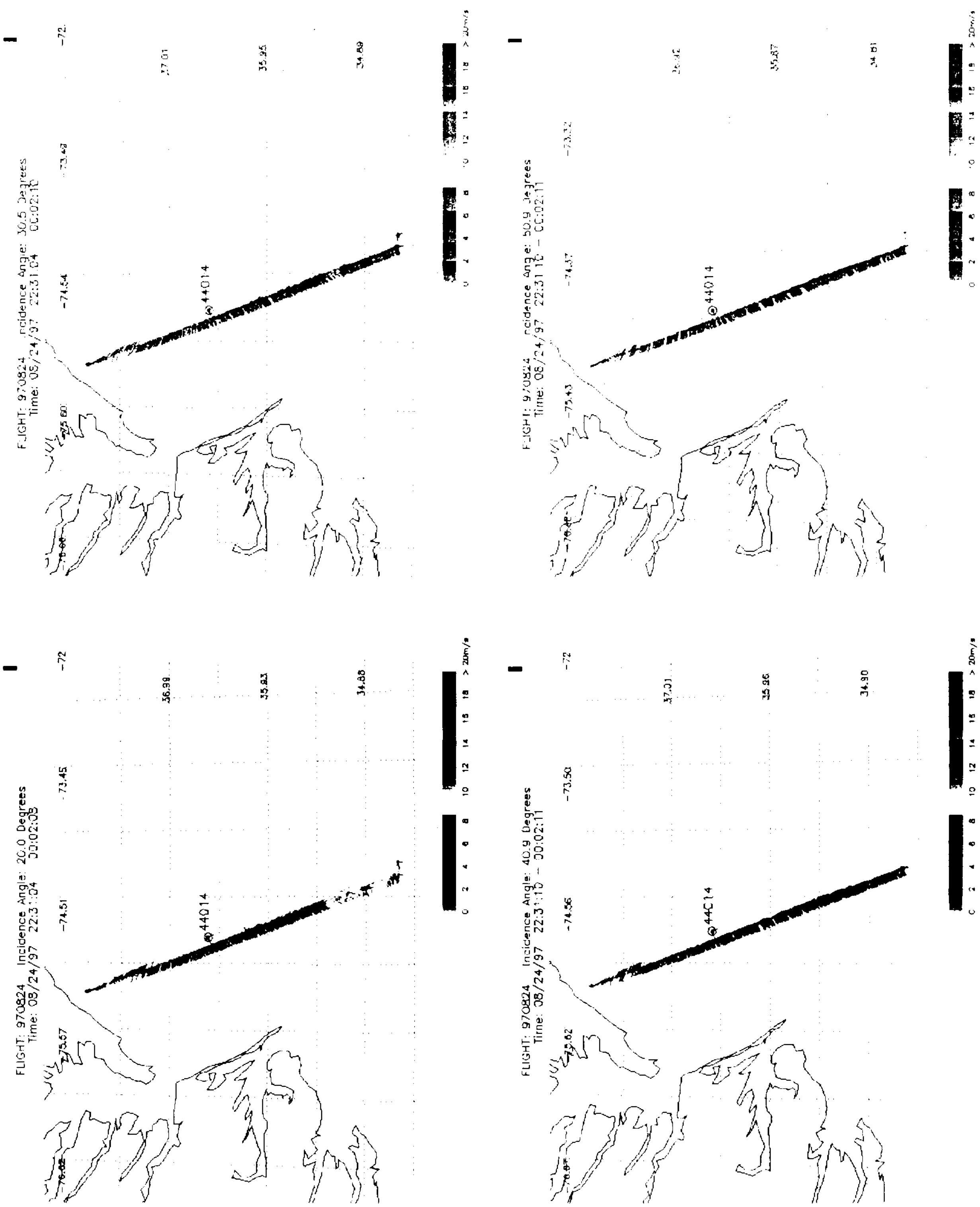

Figure 5: Plots wind vector estimates derived every one kilometer from KUSCAT data collected at 20°, 30.5°, 40.9° and 50.9° incidence on 24 September 1997. NOAA buoy locations and wind vector measurements at the time of the flight are also shown.